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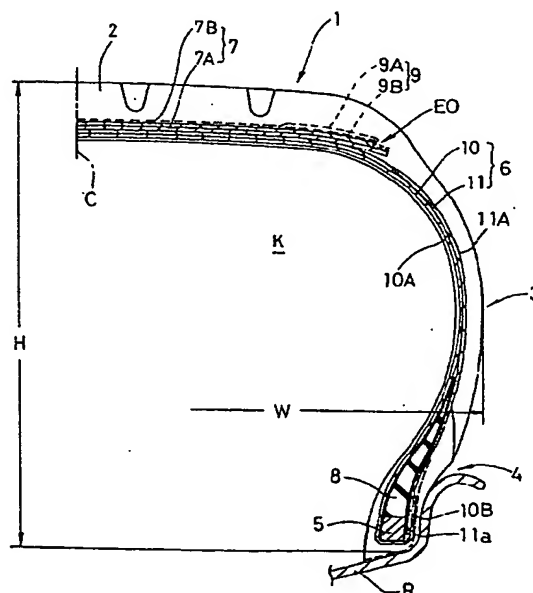
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 ⑦ Applicant : Sumitomo Rubber Industries Ltd.  
 6-9, 3-chome, Wakinohama-cho,  
 Chuo-ku  
 Kobe-shi, Hyogo-ken (JP)

⑦ Inventor : Sakamoto, Masayuki  
 13-1 Aza Higashi-onuma  
 Shirakawa-shi, Fukushima-ken (JP)  
 Inventor : Omokawa, Toshihiko  
 322-1 Aza Nakamachi,  
 Ooaza Kasaishi  
 Kagamiishi-cho, Iwase-gen, Fukushima-ken  
 (JP)  
 Inventor : Hanya, Masahiro  
 3-24 Nishi-maiko 6-chome,  
 Tarumi-ku  
 Kobe-shi, Hyogo-ken (JP)  
 ⑦ Representative : Stewart, Charles Geoffrey  
 SP TYRES UK LIMITED  
 Technical Division  
 Fort Dunlop, Erdington, Birmingham B24 9QT  
 (GB)

⑤ Pneumatic radial tyre and method of making the same

⑦ The tyre comprises a carcass (6) comprising an outer carcass ply (11,21,31) made of cords having a first heat-shrinkage-percentage K1 and an inner carcass ply (10,20,30) of cords having a second heat-shrinkage-percentage K2 different from the first heat-shrinkage-percentage K1. The cord tension of the inner carcass ply is smaller than the cord tension of the outer carcass ply. The method comprises the steps of making the outer carcass ply of cords having a first heat-shrinkage-percentage K1, making the inner carcass ply of cords having a second heat-shrinkage-percentage K2, wherein the first heat-shrinkage-percentage K1 at 150 degrees C is 120 to 160% of the second heat-shrinkage-percentage K2 at 150 degrees C, and heating and vulcanising a raw tyre to heat-shrink the outer carcass ply cords in a larger degree than the inner carcass ply.

*Fig. 1*



The present invention relates to a pneumatic tyre and a method of making the same, more particularly to an improvement relating to the carcass by which the road noise is reduced.

Recently, the requirements for less noise generation and quietness in passenger cars has been demanded. Therefore, it is necessary to decrease the noise generated from the tyres and the noise transmission rate from the tyre to the inside of the car. Road noise is one type of the noises heard in the car. Road noise has a peak in a low frequency range around 250Hz, which is almost the same as the resonance frequency of passenger cars.

During running, the tread portion of a tyre is vibrated by the roughness of the road surfaces, and the vibration is transmitted through the suspension mechanism and amplified at about 250Hz. Therefore, the inside of the car is liable to resonate or vibrate and accordingly it may become very uncomfortable for the driver. This is especially a problem for a radial tyre of which the tread portion is reinforced by a stiff belt.

It is therefore, necessary to reduce road noise to decrease the sound level of a peak around 250Hz.

In order to reduce the road noise, hitherto, the tread rubber hardness has been decreased to decrease the tread rigidity, or the tread rubber thickness has been increased to provide a cushion effect against the shock which the tread receives, or a foam rubber material has been adhered to the inner surface of the tyre as a vibration damper layer.

In such conventional countermeasures, however, fully desirable results can not be obtained. If the tread rigidity is decreased, the cornering force is decreased and the steering stability is deteriorated. If the damper layer is used, the ride comfort is impaired, and the tyre loses its weight balance about its rotational axis. Further, the tyre manufacturing process is increased in the number of the steps and the manufacturing cost increases.

It is therefore, an object of the present invention to provide a pneumatic tyre and a method of making the same, in which the noise sound level around 250 Hz can be decreased to decrease the road noise, without suffering from the above-mentioned problems.

According to one aspect of the present invention, a pneumatic tyre comprises a tread portion, a pair of axially spaced bead portions each with a bead core therein, a pair of sidewall portions, a carcass comprising an inner ply and an outer ply each extending between the bead portions, a belt disposed radially outside the carcass and inside the tread portion, wherein the outer carcass ply is made of cords having a first heat-shrinkage-percentage and the inner carcass ply is made of cords having a second heat-shrinkage-percentage K2 different from the first heat-shrinkage-percentage so that the cord tension of the inner carcass ply is smaller than the cord tension of the outer carcass ply.

Preferably the first heat-shrinkage-percentage K1 at 150 degrees C is 170 to 160% of the second heat-shrinkage-percentage K2 at 150 degrees C.

According to another aspect of the present invention, a method of making the pneumatic tyre comprises the steps of building a raw tyre by assembling the inner and outer carcass plies, and heating the raw tyre in a mould to vulcanise the tyre, wherein the outer carcass ply is made of cords having a first heat-shrinkage-percentage K1 and the inner carcass ply is made of cords having a second heat-shrinkage-percentage K2 different from the first heat-shrinkage-percentage K1, wherein the first heat-shrinkage-percentage K1 at 150 degrees C is 120 to 160% of the second heat-shrinkage-percentage K2 at 150 degrees C, whereby in the finished tyre, the cord tension of the inner carcass ply is smaller than the cord tension of the outer carcass ply.

As a result, the resonance frequency of the sidewall portions is changed to a higher frequency than 250Hz by the above-mentioned carcass construction, and the vibration transmitting percentage at 250Hz is decreased. Accordingly, resonance of the car is controlled and the road noise is reduced.

Further, as the heat-shrinkage-percentage of the inner carcass ply cords is low, the finished tyre is improved in dimensional stability and exhibits good steering stability and flat spot resistance.

An embodiment of the present invention will now be explained by way of example only according to the drawings in which:-

Fig.1 is a cross sectional view of a tyre according to the present invention;

Fig.2 is an enlarged cross sectional view of the bead portion thereof showing an example of the carcass structure;

Fig.3 is a schematic cross sectional view showing another example of the carcass structure;

Fig.4 is a cross sectional view of a tyre showing another example of the carcass structure;

Fig.5 is a schematic cross sectional view showing still another example of the carcass structure;

Fig.6 is a schematic cross sectional view showing still another example of the carcass structure;

Fig.7 is a graph showing a relationship between the heat-shrinkage-percentage ratio K1/K2 and the road noise; and

Fig.8 is a diagram for explaining crystal structures (a, b) of the carcass cord.

In the drawings, the pneumatic radial tyre 1 according to the invention comprises a tread portion 2, a pair of sidewall portions 3 each extending radially inwardly from each edge of the tread portion 2, a pair of axially

spaced bead portions 4 each located at the inner end of each of the sidewall portions 3, a pair of bead cores 5 one disposed in each of the bead portions 4, a carcass 6 extending between the bead portions 4, surrounding the tyre cavity K, a belt (7,9) disposed radially outside the carcass 6 and inside the tread portion 2, and a bead apex 8 disposed in each of the bead portions 4.

In Figs.1 and 4, is shown the tyre in its standard state mounted on its standard rim R and inflated to its standard inner pressure as specified in JIS and the like.

The tyre 1 is a low aspect ratio passenger radial tyre having an aspect ratio  $H/W$  - the ratio of the tyre section height  $H$  to the tyre maximum width  $W$  - not more than 0.70, for example 0.65.

The bead apex 8 is made of a high rigidity rubber having a substantially triangular cross-sectional shape and extending radially outwardly from the bead core 5, so as to reinforce the bead portion 4 and the sidewall lower portion. Preferably, a rubber compound having a JIS-A hardness of 80 to 95 degrees, and a complex elastic modulus  $E^*$  of 300 to 600 kg/cm<sup>2</sup> is used for the bead apex 8.

Each bead portion 4 is further provided with a chafer 12 extending along the bottom face of the bead portion 4 in order to prevent the bead portion 4 from being chafed by the rim R during running and from being damaged in the tyre to rim mounting operation. The chafer 12 is extended radially outwardly to cover the radially outer edge of a carcass turnup portion (described hereinafter).

The belt comprises a breaker belt 7 and further a bandage 9 in this embodiment.

The breaker belt 7 comprises two plies, 7A and 7B of high modulus belt cords, e.g. steel cords, aromatic polyamide fibre cords or the like, laid at a small angle of not more than 35 degrees with respect to the tyre equator C, so that the cords in one ply 7A are laid in a different direction from that in the other ply 7B to cross each other.

The bandage 9 is disposed radially outside the breaker belt 7, covering at least at axially outer edges EO of the breaker belt 7, to prevent the breaker belt 7 from being lifted during high speed running.

The bandage 9 in the example comprises a pair of axially spaced narrow width inner plies 9B disposed on the radially outside of the breaker belt 7 to cover the edges EO thereof, and an outer ply 9A disposed radially outside thereof to cover the overall width of the breaker belt 7. Each of the bandages 9A and 9B is made of low modulus cords, for example nylon, having a diameter smaller than that of the breaker cords and laid at an angle of 0 to 10 degrees with respect to the tyre equator C.

According to the invention, the carcass 6 comprises two plies, an inner carcass ply (10,20,30) and an outer carcass ply (11,21,31) each extending from one of the bead portions 4 to the other bead portion 4 through the sidewall portions 3 and under the tread portion 2. At least one of the inner and outer carcass plies is turned up around the bead cores 5 to form a pair of turnup portions. The inner and outer carcass plies are made of carcass cords arranged at an angle of from 70 to 90 degrees, in this example nearly 90 degrees, with respect to the tyre equator C. For the carcass cords, organic fibre cords, e.g. polyester, rayon, nylon or the like are used.

In Figs.1 and 2, the inner carcass ply 10 is turned up around the bead cores 5 from the inside to the outside of the tyre to form a pair of turnup portions 10B and a toroidal main portion 10A therebetween, whereby the above-mentioned bead apex 8 is positioned between the main portion 10A and the turnup portion 10B. The outer carcass ply 11 is however, not turned up around the bead cores. Therefore, it consists of a toroidal main portion 11A disposed outside the main portion 10A of the inner carcass ply 10. The radially inner edge 11a of the main portion 11A is secured between the axially outer surface of the bead apex 8 and the axially inner surface of the turnup portion 10B.

Fig.3 shows a modification of the outer carcass ply 11, in which its radially inner portion extends along the axially inner surface of the bead apex 8, and the inner edge 11a thereof is secured between the bead apex 8 and the main portion 10A.

Thus, the radially inner edge portions of the main portions 10A and 11A of the inner and outer carcass plies 10 and 11 are tightly secured to the bead cores 5 in the bead portions 4.

Fig.4 shows still another example of the carcass 6, which comprises an inner ply 20 and an outer carcass ply 21. The outer carcass ply 21 is turned up around the bead cores 5 from the inside to the outside of the tyre to form a pair of turnup portions 21B and a toroidal main portion 21A therebetween, whereby the bead apex 8 is positioned between the main portion 21A and turnup portion 21B. The inner carcass ply 20 is not turned up around the bead cores. Therefore, it consists of a toroidal main portion 20A extending along and adjacent to the inner surface of the main portion 21A. The inner edges 20a thereof terminate at the almost same height as the radially inner end of the bead core 5.

Fig.5 shows a modification of the inner carcass ply 20, in which the inner carcass ply 20 is also turned up around the bead cores 5 so as to form a turnup portion 20B in the same way as the outer carcass ply 21. In this case, the turnup portion 20B is preferably extended radially outwardly to completely cover the turnup portion 21B of the outer carcass ply 21.

Fig.6 shows a modification of the carcass 6 shown in Figs.1 and 2. In this example, the inner carcass ply 30 comprises a main portion 30A and a pair of turnup portions 30B turned up around the bead cores 5 from the axially inside to the outside. The outer carcass ply 31 is not turned up, and the radially inner edge 31a is disposed axially outside of the turnup portion 30B of the inner carcass ply 30, and terminates near the bead core 5.

In any case, the radially inner edges 11a (Figs.1-3), 20a (Fig.4) and 31a (Fig.6) terminate within a range Y between the radially inner and outer surfaces of the bead core. As a result, shear stress concentration on the inner edge when the bead is deformed, can be prevented.

On the other hand, the radially outer edges of the turnup portions 10B (Figs.1-3), 21B (Fig.4), 20B-21B (Fig.5) and 30B (Fig.6) terminate at a height  $H_m$  radially outwards of the radially outer end of the bead core 5 but radially inwards of the radially outer edge of the flanges of the rim R, to thereby avoid the shear stress concentration on the edge.

According to the invention, the cord tension of the outer carcass ply is set to be larger than the cord tension of the inner carcass ply in the finished tyre.

To achieve this, in the process of building a raw tyre, organic cords having different heat-shrinkage-percentages K1 and K2 are used to make the raw carcass plies. Then, to vulcanise the raw materials, the tyre is put into a mould and heated while pressurising the inside of the tyre.

In order to practice such a process, the nowadays widely used tyre making methods can be utilised. Explained briefly, such tyre making methods comprises the following steps or processes: the raw carcass plies are wound around a cylindrical drum's surface; the bead cores and bead apexes are disposed thereon while providing a space therebetween; then while decreasing the space between the bead cores, the drum is expanded so that the carcass is shaped to a toroidal shape; on the crown portion of the carcass, the breaker plies and band plies are disposed; a rubber tread, sidewalls, beads and other layers are disposed thereon to form a raw tyre. Then the raw tyre is put in a mould and vulcanised.

According to the present invention, the cords for the outer carcass ply (11,21,31) have a first heat-shrinkage-percentage K1 and the cords for the inner carcass ply (10,20,30) have a second heat-shrinkage-percentage K2 which is different from K1. Thus a plurality of organic cords having the second heat-shrinkage-percentage K2 are laid parallel with each other and embedded in topping rubber in the form of rubber sheet. This sheet is cut in a suitable size and wound around the above-explained drum as the raw inner carcass ply (10,20,30). Similarly, a plurality of organic cords having the first heat-shrinkage-percentage K1 are laid parallel with each other and embedded in topping rubber in the form of rubber sheet and cut in a suitable size. This sheet is wound around the previously wound inner carcass ply as the raw outer carcass ply (11,21,31) so that the inner carcass ply cords cross the outer carcass ply cords at a small angle.

Thereafter, in the tyre vulcanising process, these raw plies are heated and then cooled. As a result, through the vulcanising process, the outer carcass ply cords are heat-shrunk to a larger degree than the inner carcass ply cords, and the outer carcass ply is greatly increased in cord tension than the inner carcass ply in the finished tyre.

Here, the first heat-shrinkage-percentage K1 is set in the range of from 120 to 160%, more preferably 130 to 150%, of the second heat-shrinkage-percentage K2. If K1 is less than 120% of K2, the noise reduction is insufficient. If K1 is more than 160% of K2, the tyre rigidity decreases and the steering stability is deteriorated, and further, the noise has a tendency to increase.

In order to maintain the dimensional stability of the finished tyre, the heat-shrinkage-percentage K2 of the inner carcass ply is preferably set in the range of from 3.5 to 5.0%.

The above-mentioned heat-shrinkage-percentage is obtained as follows. First, the original length (x) of the cord is measured, and the cord is put in a 150 degrees C atmosphere for 20 minutes without being loaded. Then the length (z) of the heat-shrunk cord is measured to find the heat shrinkage (y). ( $y=x-z$ ). The heat-shrinkage-percentage is calculated as  $(y/x) \times 100$ .

The above-mentioned difference between the heat-shrinkage-percentages K1 and K2 can be provided as follows.

When the inner carcass ply is materially the same as the outer carcass ply, the difference is provided by heat-shrinking both the inner and outer carcass ply cords prior to vulcanisation under different heat-treating conditions, e.g. heating time, temperature and the like, or alternatively, by heat-shrinking only the inner carcass ply cords prior to vulcanisation to decrease the heat-shrinkage-percentage K2.

Further, during treating the cord by dipping into resin or latex, by changing the cord tension, the heat-shrinkage-percentage can be changed. If the cord tension is increased during dip treating, the heat-shrinkage during tyre vulcanisation is increased.

Furthermore, in the case of the same material, the crystal structure of the cord may be changed. For example, a regular polyester cord and a high-modulus polyester cord may be used.

Figs.8 (a) and (b) diagrammatically show the crystal structure of a regular polyester and that of a high modulus polyester. In Figs.8 (a) and (b), 15 is the crystal region, and 16 is the amorphous region. Between the regular modulus polyester and high modulus polyester, the size, percentage, orientation of such regions are differed. The high modulus polyester exhibits a low heat-shrinkage-percentage, and the regular polyester a higher heat-shrinkage-percentage.

Still furthermore, different cord materials may be used. For example, a nylon fibre cord and a polyester fibre cord.

However, the same material cords are preferably used in view of tyre performances.

Fig.7 shows a relationship between the ratio  $K1/K2$  and road noise obtained in a test of tyres according to the invention.

In the test, tyres of size 215/65R15 mounted on a standard rim of 15X6 1/2JJ and inflated to a pressure of 2.0 ksc were installed on the front and rear wheels of a FR-type passenger car. Then, the test car was run on a rough asphalt road at a constant speed of 50 km/h, and the noise was measured in the car near the driver's ear on the inner side of the car.

As shown in Fig.7, as the ratio  $K1/K2$  increased, the overall noise decreased, and the 250Hz noise especially decreased when the ratio  $K1/K2$  was in the range of from 1.20 to 1.60.

Test tyres of size 215/65R15 having the same structure shown in Fig.1 excepting the carcass constructions, were prepared and tested for road noise, steering performance, ride comfort, flat spot resistance and tyre uniformity.

The specifications and test results are shown in Table 1 and Table 2.

The road noise was measured in the same way as in the noise test mentioned in relation to Fig.7. In Tables 1 and 2, the noise in each carcass construction (Fig.1-2, 6, 7, 8 or 3) is expressed in decibels as the difference from a conventional arrangement ( $K1=K2$ ).

The ride comfort and steering stability were evaluated by the driver while running on a dry asphalt road.

The flat spot resistance was evaluated by the driver while running at 60 km/h for 1 km after the test tyre (size:215/65R15) mounted on the standard rim (size:15X6 1/2JJ) and inflated to the standard inner pressure (2.0ksc) and loaded with 500 kg was kept not moving for five days.

The tyre uniformity, the radial force variation (RFV), was measured according to JASO-C607 (Test method for automobile tyre uniformity).

In the case where both the inner and outer carcass plies were made of the materially same regular polyester cords, in order to provide a difference in the heat-shrinkage-percentages, the cords underwent different heat treatments before vulcanising the tyre.

[Table 1]

5		Ex.a1	Ex.a2	Ex.a3	Ex.a4	Ex.a5	Conven.a	Ref.a1	Ref.a2
	CARCASS								
	Construction	Fig.1, 2							
10	Hm (mm)	20							
	Hd (mm)	6							
15	Inner carcass ply								
	No. of ply	1	1	1	1	1	1	1	1
	Ply type #1	TUP	TUP	TUP	TUP	TUP	TUP	TUP	TUP
	Cord material #2	HM-PE	HM-PE	HM-PE	HM-PE	HM-PE	HM-PE	HM-PE	RG-PE
		1500d/2	1500d/2	1500d/2	1500d/2	1500d/2	1500d/2	1500d/2	1500d/2
	Finished cord count (ends/5cm)	53.5	53.5	53.5	53.5	53.5	53.5	53.5	53.5
	Cord angle (deg.)	90	90	90	90	90	90	90	90
	Heat shrinking percentage K2(%)	4.7	4.7	4.7	4.7	4.7	4.7	4.7	7.0
20	Outer carcass ply								
	No. of ply	1	1	1	1	1	1	1	1
	Ply type #1	DWN	DWN	DWN	DWN	DWN	DWN	DWN	DWN
	Cord material #2	RG-PE	RG-PE	RG-PE	RG-PE	RG-PE	HM-PE	RG-PE	RG-PE
		1500d/2	1500d/2	1500d/2	1500d/2	1500d/2	1500d/2	1500d/2	1500d/2
	Finished cord count (ends/5cm)	53.5	53.5	53.5	53.5	53.5	53.5	53.5	53.5
	Cord angle (deg.)	90	90	90	90	90	90	90	90
	Heat shrinking percentage K2(%)	5.7	6.0	6.5	7.0	7.5	4.7	8.0	7.0
	K1/K2 ratio	1.21	1.28	1.38	1.49	1.59	1.0	1.70	1.0
30	BELT								
	No. of ply	2	2	2	2	2	2	2	2
	Cord material	steel	steel	steel	steel	steel	steel	steel	steel
	Finished cord count (ends/5cm)	34	34	34	34	34	34	34	34
	Finished cord angle (deg.)	24	24	24	24	24	24	24	24
35	Test Result #3								
	Noise								
	Overall	-0.2	-0.6	-1.0	-1.2	-1.2	0	-1.3	-1.3
	125Hz	-0.2	-0.5	-0.8	-0.9	-0.9	0	-1.0	-0.8
	250Hz	-0.4	-1.0	-1.5	-1.7	-1.8	0	-1.9	-1.8
40	Steering stability	A	A	A	A	B	A	C	A
	Ride comfort	A	A	A	A	A	A	B	A
	Flat spot resistance	A	A	A	A	A	A	A	B
	Tire uniformity	A	A	A	A	A	A	A	A

1) TUP = turned up DWN = not turned up

2) HM-PE = High modulus polyester RG-PE = Regular polyester

3) A = Good, B = a little no good, C = No good

[Table 2]

	Ex.b	Conven.b	Ex.c	Conven.c	Ex.d	Conven.d	Ex.e	Conven.e
CARCASS Construction	Fig.4		Fig.5		Fig.6		Fig.3	
Hm(mm) Hd(mm)	20 6		Hm2=20, Hm1=10 --		20 6		20 6	
Inner carcass ply								
No. of ply	1	1	1	1	1	1	1	1
Ply type #1	TUP	TUP	TUP	TUP	TUP	TUP	TUP	TUP
Cord material #2	HM-PE	HM-PE	HM-PE	HM-PE	HM-PE	HM-PE	HM-PE	HM-PE
	1500d/2	1500d/2	1500d/2	1500d/2	1500d/2	1500d/2	1500d/2	1500d/2
Finished cord count (ends/5cm)	53.5	53.5	53.5	53.5	53.5	53.5	53.5	53.5
Cord angle (deg.)	90	90	90	90	90	90	90	90
Heat shrinking percentage K2(%)	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
Outer carcass ply								
No. of ply	1	1	1	1	1	1	1	1
Ply type #1	DWN	DWN	DWN	DWN	DWN	DWN	DWN	DWN
Cord material #2	RG-PE	HM-PE	RG-PE	HM-PE	RG-PE	HM-PE	RG-PE	HM-PE
	1500d/2	1500d/2	1500d/2	1500d/2	1500d/2	1500d/2	1500d/2	1500d/2
Finished cord count (ends/5cm)	53.5	53.5	53.5	53.5	53.5	53.5	53.5	53.5
Cord angle (deg.)	90	90	90	90	90	90	90	90
Heat shrinking percentage K2(%)	6.5	4.7	6.5	4.7	6.5	4.7	6.5	4.7
K1/K2 ratio	1.38	1.0	1.38	1.0	1.38	1.0	1.38	1.0
BELT								
No. of ply	2	2	2	2	2	2	2	2
Cord material	steel	steel	steel	steel	steel	steel	steel	steel
Finished cord count (ends/5cm)	34	34	34	34	34	34	34	34
Finished cord angle (deg.)	24	24	24	24	24	24	24	24
Test Result #3								
Noise								
Overall	-0.9	0	-1.1	0	-0.2	0	-0.9	0
125Hz	-0.7	0	-0.8	0	-0.1	0	-0.7	0
250Hz	-1.4	0	-1.6	0	-0.4	0	-1.5	0
Steering stability	A	A	A	A	A	A	A	A
Ride comfort	A	A	A	A	A	A	A	A
Flat spot resistance	A	A	A	A	A	A	A	A
Tire uniformity	A to B	A	B	A	A	A	A	A

1) TUP = turned up DWN = not turned up

2) HM-PE = High modulus polyester RG-PE = Regular polyester

3) A = Good, B = a little no good, C = No good

## Claims

1. A pneumatic tyre comprising a tread portion (2), a pair of axially spaced bead portions (4) with a bead core (5) therein, a pair of sidewall portions (3), a carcass (6) comprising an inner ply (10,20,30) and an outer ply (11,21,31) each extending between the bead portions (4), a belt (7,9) disposed radially outside the carcass (6) and inside the tread portion (2), characterised in that the outer carcass ply (11,21,31) is made of cords having a first heat-shrinkage-percentage K1 and the inner carcass ply (10,20,30) is made

of cords having a second heat-shrinkage-percentage K2 different from the first heat-shrinkage-percentage K1 and in the finished tyre the cord tension of the inner carcass ply (11,21,31) is smaller than the cord tension of the outer carcass ply (10,20,30).

- 5     2. A pneumatic tyre according to claim 1, characterised in that the first heat-shrinkage-percentage K1 at 150 degrees C is 120% to 160% of the second heat-shrinkage-percentage K2 at 150 degrees C.
- 10     3. A pneumatic tyre according to claim 1, characterised in that the inner carcass ply (10) is turned up around the bead cores (5) from the axially inside to outside thereof to form a pair of turnup portions (10B), and the outer carcass ply (11) is not turned up around the bead cores so that each of the radially inner edges thereof terminates near the axially inside or outside of the bead core (5).
- 15     4. A pneumatic tyre according to claim 3, characterised in that the radially inner ends of the outer carcass ply (11) are disposed on the axially inside of the turnup portions of the inner carcass ply (10).
- 20     5. A pneumatic tyre according to claim 1, characterised in that the outer carcass ply is turned up around the bead cores from the axially inside to outside to form a pair of turnup portions.
- 25     6. A method of making a pneumatic tyre comprising steps of building a raw tyre including the steps of assembling the inner and outer carcass plies, and heating the raw tyre in a mould to vulcanise the tyre, characterised in that the outer carcass ply (11,21,31) is made of cords having a first heat-shrinkage-percentage K1 and the inner carcass ply (10,20,30) is made of cords having a second heat-shrinkage-percentage K2 different from the first heat-shrinkage-percentage K1, and the first heat-shrinkage-percentage K1 at 150 degrees C is 120 to 160 % of the second heat-shrinkage-percentage K2 at 150 degrees C, whereby the heating is to a temperature such that in the finished tyre, the cord tension of the inner carcass ply is smaller than the cord tension of the outer carcass ply.

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Fig. 1

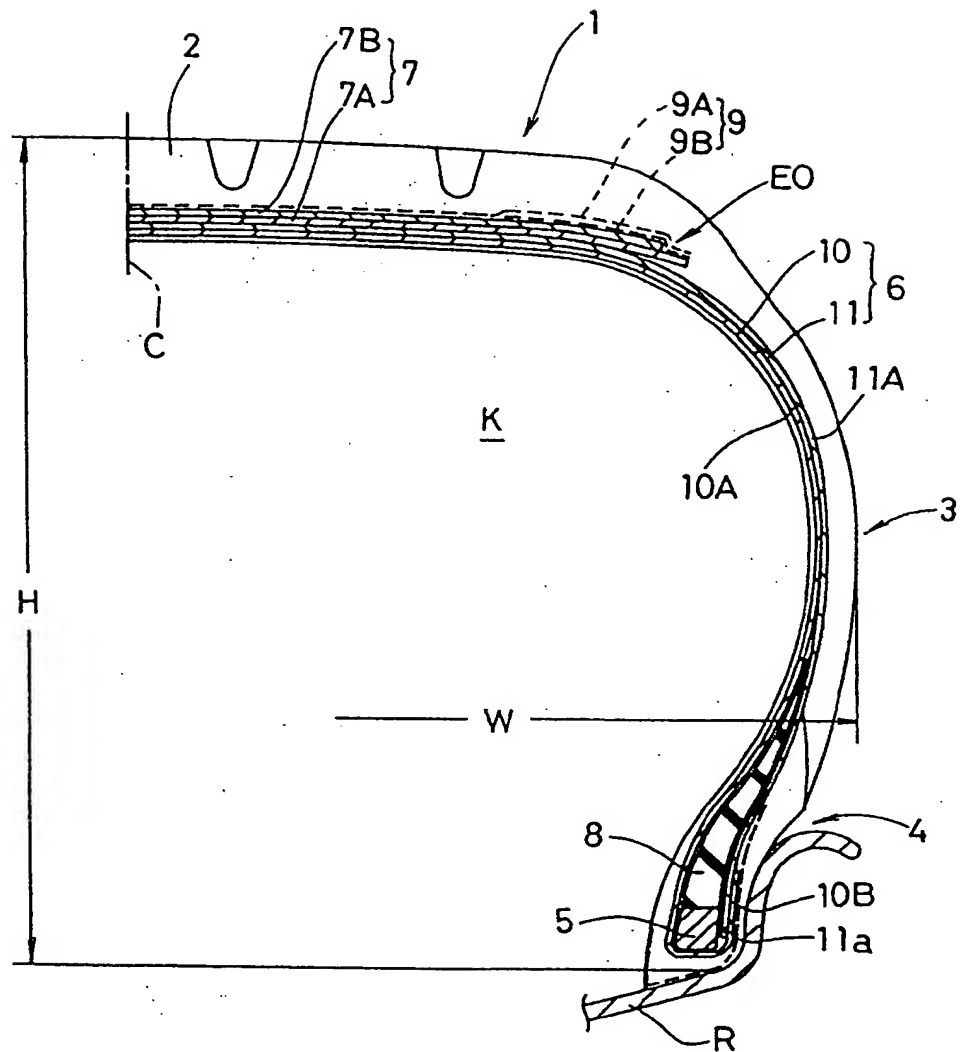


Fig. 2

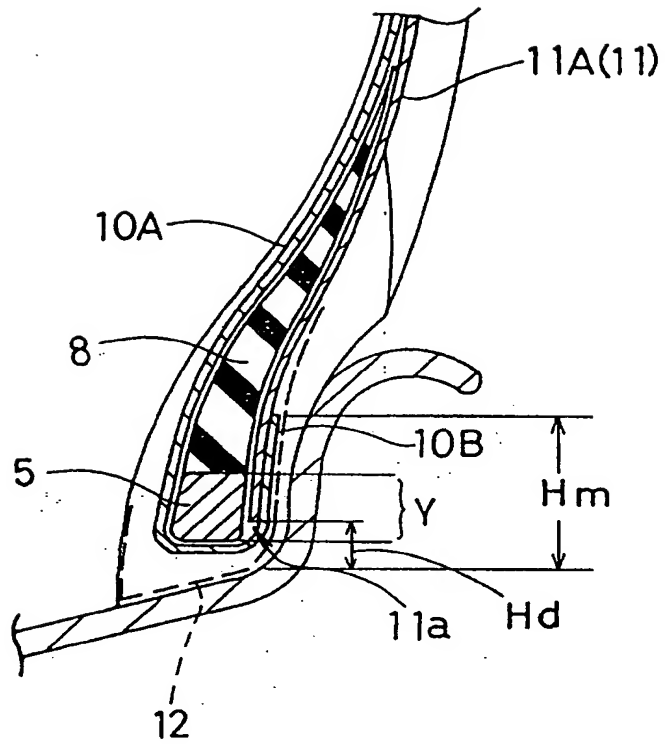


Fig. 3

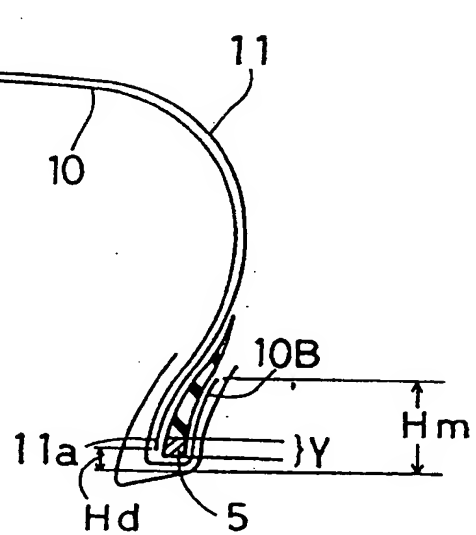


Fig. 4

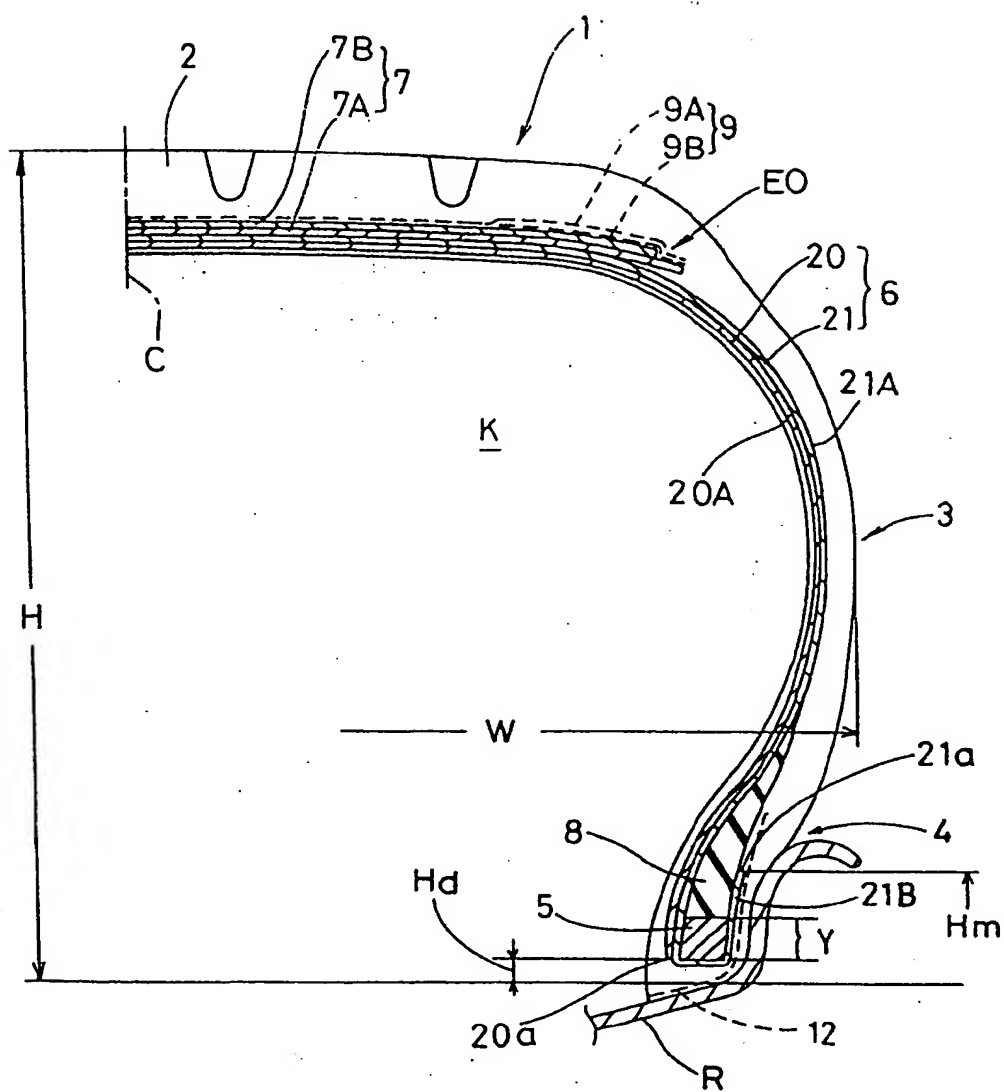


Fig. 5

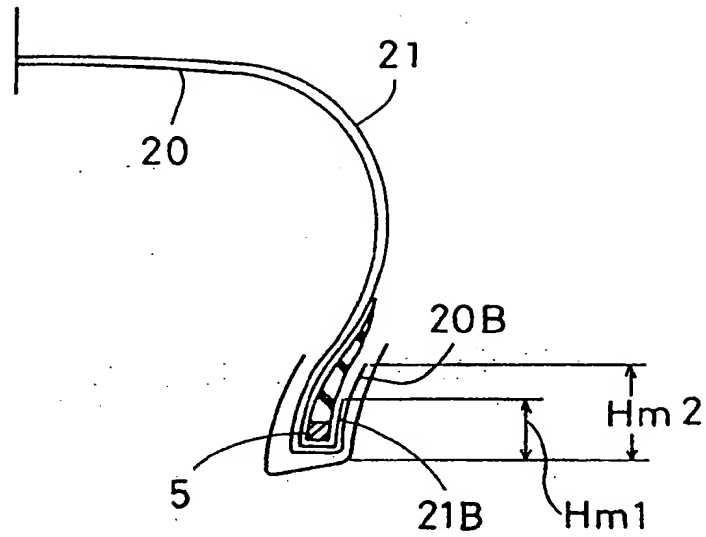
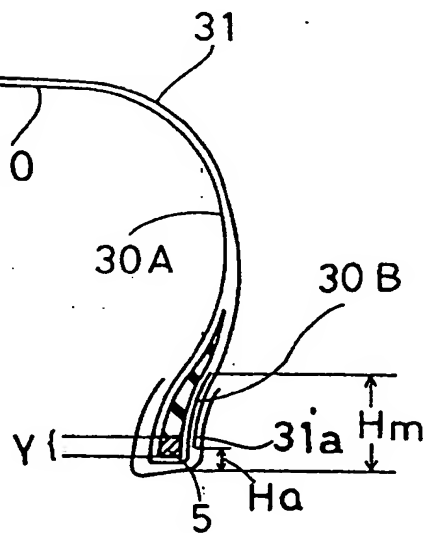
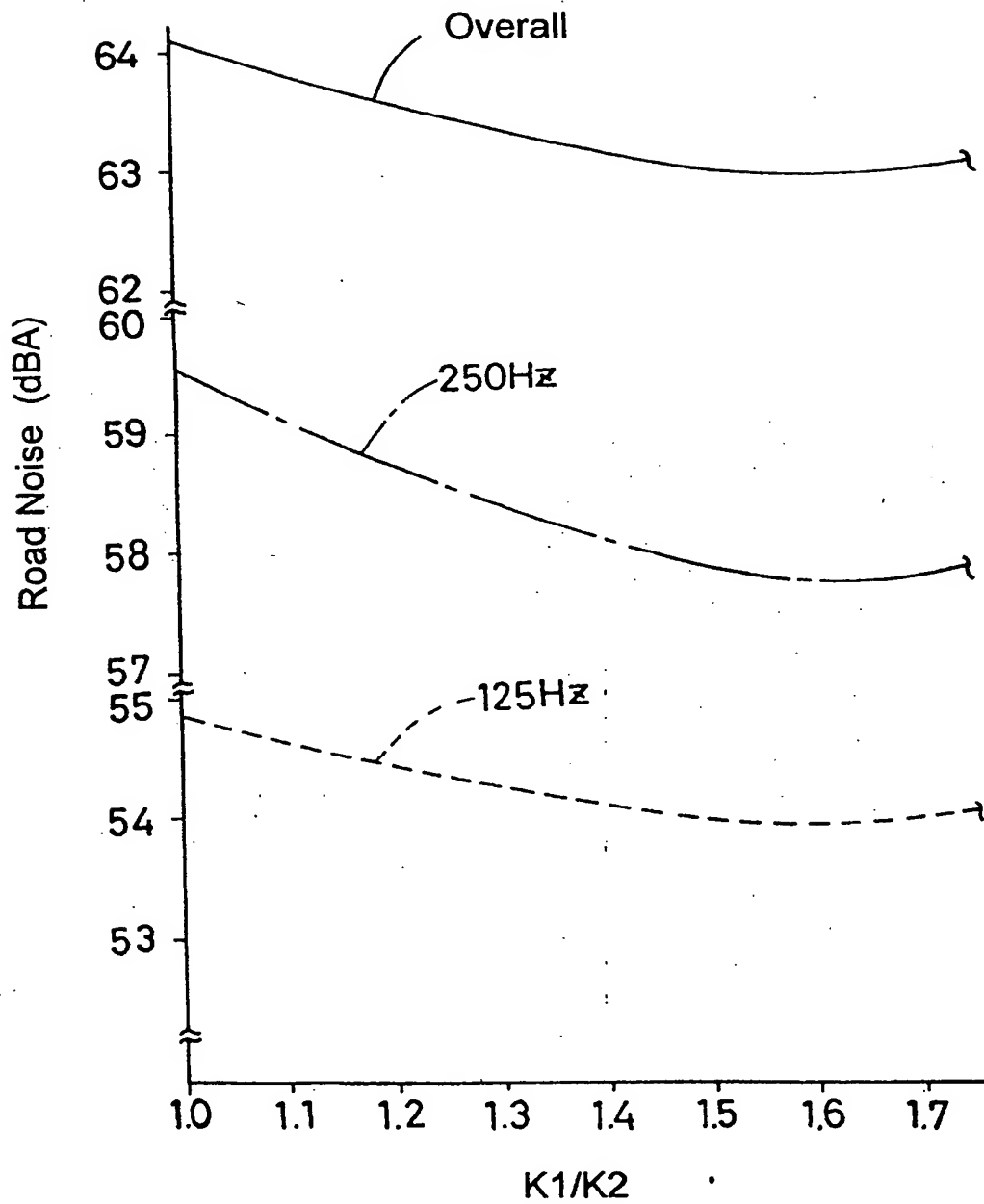


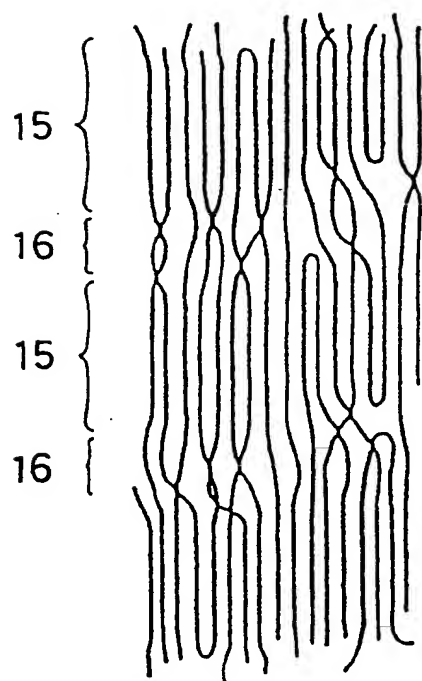
Fig. 6



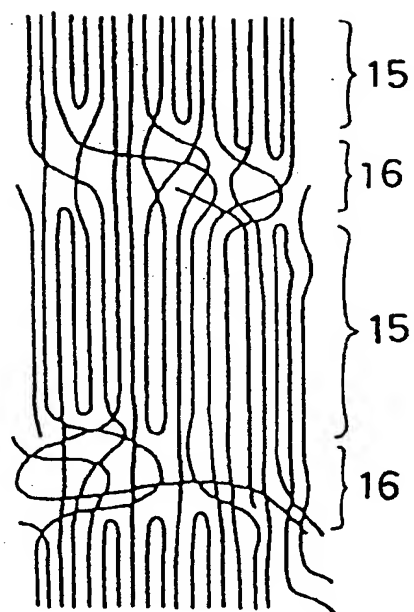
*Fig. 7*

*Fig. 8*

(a)



(b)



(19)



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(11)

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(71) Applicant: Sumitomo Rubber Industries Ltd.  
Kobe-shi, Hyogo-ken (JP)

(72) Inventors:  
• Sakamoto, Masayuki  
Shirakawa-shi, Fukushima-ken (JP)

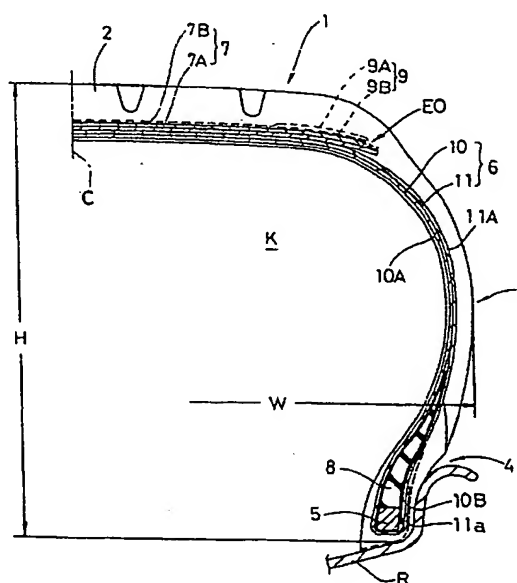
• Omokawa, Toshihiko  
Kagamiishi-cho, Iwase-gen, Fukushima-ken (JP)  
• Hanya, Masahiro  
Kobe-shi, Hyogo-ken (JP)

(74) Representative: Stewart, Charles Geoffrey  
SP TYRES UK LIMITED  
Technical Division  
Fort Dunlop, Erdington,  
Birmingham B24 9QT (GB)

(54) Pneumatic radial tyre and method of making the same

(57) The tyre comprises a carcass (6) comprising an outer carcass ply (11,21,31) made of cords having a first heat-shrinkage-percentage K1 and an inner carcass ply (10,20,30) of cords having a second heat-shrinkage-percentage K2 different from the first heat-shrinkage-percentage K1. The cord tension of the inner carcass ply is smaller than the cord tension of the outer carcass ply. The method comprises the steps of making the outer carcass ply of cords having a first heat-shrinkage-percentage K1, making the inner carcass ply of cords having a second heat-shrinkage-percentage K2, wherein the first heat-shrinkage-percentage K1 at 150 degrees C is 120 to 160% of the second heat-shrinkage-percentage K2 at 150 degrees C, and heating and vulcanising a raw tyre to heat-shrink the outer carcass ply cords in a larger degree than the inner carcass ply.

Fig. 1



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## EUROPEAN SEARCH REPORT

Application Number  
EP 95 30 3936

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	PATENT ABSTRACTS OF JAPAN vol. 016 no. 331 (M-1282) ,20 July 1992 & JP-A-04 095502 (BRIDGESTONE CORP) 27 March 1992, * abstract *	1-6	B60C9/08 B60C9/06
X	--- PATENT ABSTRACTS OF JAPAN vol. 015 no. 458 (M-1182) ,21 November 1991 & JP-A-03 197204 (TOYO TIRE & RUBBER CO LTD) 28 August 1991, * abstract *	1,3-6	
X	--- DE-A-38 25 515 (TOYO TIRE & RUBBER CO) 9 February 1989 * page 3, line 6 - line 21; claims; figures *	1,3-6	
X	--- FR-E-90 220 (MICHELIN ET CIE) * claims; figures *	1,6	
X	--- US-A-3 245 454 (K.R. LEWIS) * claims; figure 1 *	1	TECHNICAL FIELDS SEARCHED (Int.Cl.6) B60C
A	--- PATENT ABSTRACTS OF JAPAN vol. 013 no. 432 (M-874) ,27 September 1989 & JP-A-01 164603 (OHTSU TIRE & RUBBER CO LTD:THE) 28 June 1989, * abstract *	1	
A	--- FR-A-2 075 851 (MICHELIN ET CIE) 15 October 1971 * page 3, line 23 - line 32; claims 4-6; figures *	1	
-----			
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 1 March 1996	Examiner Baradat, J-L
<b>CATEGORY OF CITED DOCUMENTS</b> X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ..... & : member of the same patent family, corresponding document			

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